

EMISSION FROM SMALL DUST PARTICLES IN DIFFUSE AND MOLECULAR CLOUD MEDIUM

J.P. Bernard¹, X. Désert²

¹ Institut d'Astrophysique Spatiale, Université Paris XI, bât. 210, 91401 Orsay Cedex, France

² NASA Goddard Space Flight Center, Code 685, Greenbelt, MD 20771, USA

IRAS observations of the whole galaxy has shown that long wavelength emission (100 and 60 μm bands) can be explained by thermal emission from big grains ($\approx 0.1 \mu\text{m}$) radiating at their equilibrium temperature when heated by the Inter Stellar Radiation Field (ISRF). This conclusion has been confirmed by continuum sub-millimeter observations of the galactic plane made by the EMILIE experiment at 870 μm (Pajot et al 1986). Nevertheless, shorter wavelength observations like 12 and 25 μm IRAS bands, show an emission from the galactic plane in excess with the long wavelength measurements which can only be explained by a much hotter particles population. Because dust at equilibrium cannot easily reach high temperatures required to explain this excess, this component is thought to be composed of very small dust grains or big molecules encompassing thermal fluctuations.

We present here a numerical model that computes emission, from NIR to Sub-mm wavelengths, from a non-homogeneous spherical cloud heated by ISRF. This model fully takes into account the heating of dust by multi-photon processes and back-heating of dust in the VIS-IR so that it is likely to describe correctly emission from molecular clouds up to large A_V and emission from dust experiencing temperature fluctuations. The dust is a three component mixture of PAHs (Polycyclic Aromatic Hydrocarbons), VSGs (Very Small Grains) and classical BGs (Big Grains) with independent size distributions (cut-off and power law index) and abundances.

The presence of PAHs in the ISM has been inferred for the first time to explain the unidentified IR bands at 3.3, 7.6, 7.7, 8.6 and 11.3 μm (Léger, Puget 1984, Allamandola et al 1985) observed in various objects ranging from planetary nebulae to external galaxies. They seem to be ubiquitous in the extended ISM of our galaxy as revealed by the AROME experiment which as mapped the galactic disk in the 3.3 μm band (Giard et al 1988). This plane molecules are so small dust particles that they can reach high vibrational temperatures (once a day in ISM environment) after absorption of a single UV photon by electronic transitions followed by internal redistribution of its energy between the vibrational modes. The molecule therefore cools by emitting IR photons (most of them in the 12 μm IRAS band) during only a few seconds so

that PAHs are the most extreme case of ISM particles emitting IR energy in an out-of-equilibrium stage. Moreover, recent laboratory measurements have shown that this molecules absorbs significantly in the non-linear FUV rise part of the extinction curve (Léger et al 1988) so that they play an important role in the radiation transfer from the edge of a cloud towards the center.

To account for the 12 μm emission, bigger grains are needed that are no longer two dimensional but three dimensional (VSGs). They are supposed to be carbon-dominated in the model and to account for most of the 2200 Å bump observed in the extinction curve.

BGs are considered as the carrier of the visible part of the extinction curve. As proposed by Chlewicki and Greenberg (1988), we have supposed that they are made of silicates coated by carbon dominated material. This has the advantage to explain both the width of the 9.7 and 18 μm absorption of silicates and the 3.4 μm absorption towards the galactic center.

The mass abundance relative to hydrogen (Y) and the size distribution parameters (radius cut-off a_{min} and a_{max} and size distribution power law index α) of each component has been optimized to fit the emission and extinction observed in the diffuse HI medium of our galaxy (see Table 1).

Fig 1 is a plot of IRAS brightness against position of the line of sight toward various A_V clouds with r^{-2} gas density distribution and dust characteristics of table 1. The separation of the curves at low radii is due to including back-IR heating. No limb brightening effect at 12 μm is obtained until high A_V are reached. Fig 2 shows the incident spectrum at various positions inside the $A_V=100$ mag cloud. The initial ISRF is progressively attenuated when penetrating into the cloud. The hatched area represents the effect of including back-IR heating.

Real cases of clouds with observed colors variations have also been emphasized. We find that IRAS colors variations with position in the cloud are not likely to be due to transfer effects but to abundance variations of the various dust species. For instance, G299-16, an high 12/100 cloud of the Chameleon complex, shows a decrease of 12 and 25 μm at the center which can only be explained by a strong decrease of PAHs abundance at $n_H > 400\text{-}500 \text{ H/cm}^3$ in the cloud.

References:

- Allamandola L. J., Tielens A.G.G.M. and Barker J.R. 1985, *Astrophys. J. (Letters)*, **290**, L25
 Chlewicki G. and Greenberg M. 1988, *Astrophys. J.*, submitted
 Giard M., Pajot F., Lamarre J.M., Serra G., Audouze J., Caux E., Combes M., Gispert R., Léger A. and Rouan D. 1988, *Astron. & Astrophys. Let.* **201**, L1
 Léger A., Puget J.L. 1984, *Astron. & Astrophys.*, **137**, L5
 Léger A., d'Hendecourt L. and Defourneau, D. 1988 *Astron. & Astrophys.*, submitted
 Pajot F., Gispert R., Lamarre J.M., Peytureaux R., Puget J.L., Serra G., Coron N., Dambier G., Leblanc J., Moalic J.P., Renaud J.C. and Vitry R. 1986, *Astron. & Astrophys.*, **154**, 55.

Table 1

	Y (10^{-4})	a _{min} (nm)	a _{max} (nm)	α
PAHs	4.6	.4	12	-3.0
VSGs	4.7	12	15	-3.1
BGs	64	15	110	-2.8

H-coverage for PAHs: 0.4

Fig 1

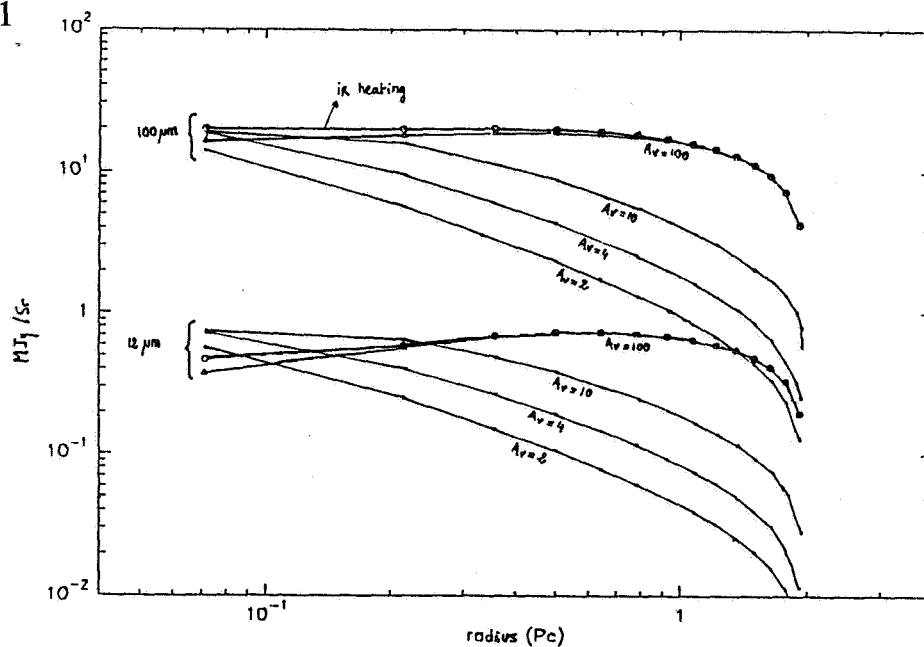


Fig 2

